OBSERVATIONS ON THE RELATIONSHIPS BETWEEN A VESICULAR-ARBUSCULAR FUNGUS, A FUNGIVOROUS NEMATODE, AND THE GROWTH OF SOYBEANS [1]

E. O. SALAWU [2] and R. H. ESTEY

Department of Plant Science, Macdonald College, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada.

Phytoprotection **60 (2)**: 99-102 (1979)

ABSTRACT

Simultaneous addition of a vesicular-arbuscular mycorrhizal fungus, *Glomus* sp. and *Aphelenchus avenae*, a fungivorus nematode, to root zone soil, significantly inhibited the development of shoots and roots of soybean plants. It was demonstrated experimentally that the nematode was responsible for poor sporulation of the fungus. Fewer nodules were found on plants treated with both *A. avenae* and the *Glomus* sp. than on those treated with the mycorrhizal fungus alone.

RÉSUMÉ

Glomus sp., un champignon mycorhizateur à vésicules et à arbuscules, et *Aphelenchus avenae*, un nématode fongivore, ont empêche de façon significative le développement des tiges et des racines des plants de soya lorsqu'ils ont été ajoutés simultanément à la rhizosphère. Il a été démontré expérimentalement qu'une faible sporulation du champignon était due à la présence du nématode. Les plants traités avec *A. avenae* et *Glomus* sp. présentaient moins de nodules que ceux traités uniquement avec le champigon mycorhizateur.

Fungi that produce vesicular-arbuscular (VA) mycorrhizae are of particular interest because of the large number of agricultural crops on which they occur. For exemple, they occur on the leguminosae (Asai 1964) which are of great economic importance. However, few studies have been carried out on the effect of these mycorrhizal fungi on other micro-organisms or vice versa ; Ross (1972) found that an endomycorrhizal fungus, *Endogone sp.*, increased the susceptibility of soybean, *Glycine max* (L) Merril, to *Phytophthora megasperma* Drechs. var *sojae* Hildeb. Baltruschat *et al.* (1973) indicated that *Endogone mosseae* Nicol. and Gerd. had an antagonistic effect on the parasitism of both *Thielavia basicola* (Berk. and Br.) Zopf and *Meloidogyne incognita* (Kofoid and White) Chitwood

[1] Part of a M.Sc. thesis submitted by the senior author to McGill University, Montreal, P.Q., Canada.

[2] Present address: Nematology Division, National Cereals Research Institute, P.M.B. 5042. Moor Plantation, Ibadan Nigeria.

on tobacco (*Nicotiana tobacum* L.). Schenck *et al.* (1975) reported that an increase in the number of root-knot nematodes, *M. incognita,* decreased the yield of Pickett and Ransom cultivars of soybeans and greatly reduced the sporulation and infectivity of endomycorrhizal fungi.

The present work investigates the effect of a combination of a VA endomycorrhizal fungus and a fungivorous nematode on the growth of soybean.

MATERIALS AND METHODS

The strain of *Aphelenchus avenae* Bastian, a nematode that is primarily fungivorous, was obtained from a culture originally isolated from local soil and maintained in the laboratory on *Rhyzoctonia solani* Kuhn. Spores of the VA endomycorrhizal fungus used as inoculum were extracted from soybean field soil by means of a centrifuge-sugar flotation technique similar to the one used by Caveness and Jensen (1955).

Seeds of soybean, cultivar Altona, surface sterilized in 1,5% NaCl for ten minutes and washed with sterile water, were sown in 15 cm diameter clay pots which were filled with steam-sterilized topsoil. One week after germination, the seedlings were thinned to one plant per pot, and the soil around the roots was inoculated by pipetting known numbers of *A. avenae* and spores of the *Glomus* sp. into the root-zone soil. The experiments consisted of the following three treatments replicated five times : (1) Test plant, (2) Test plant + 100 spores of *Glomus* + 32 000 larvae and adults of *A. avenae.* An earlier test series (Salawu 1977) had shown that 32 000 *A. avenae* had no effect on the growth of Altona soybeans during the period of 60 days. For this reason, and because of a shortage of inoculum, a nematode alone treatment was not included in this test. Pots containing the plants were raised off the bench-top with perforated plastic dishes, and randomly arranged in a greenhouse where the temperature fluctuated between 21°C and 24°C. During the test, 100 mg NH_4NO_3 was added to the soil of each pot to provide the plant with additional nutrient. All plants were removed from the pots 45 days after inoculation and fresh weights of their roots and shoots were recorded. After being weighed, segments of some roots were taken randomly from plants inoculated with *Glomus* spores alone, and from those inoculated with spores plus nematodes. These were stained in boiling 0,1% cotton blue lactophenol, washed to remove excess stain, cleared in pure lactophenol and then sectioned.

EXPERIMENTAL RESULTS

The data from this experiment are summarized in Table 1. It can be seen that simultaneous addition of *Glomus* spores and *A. avenae,* compared with *Glomus* spores alone, resulted in reduced growth of the soybean plants. The leaves of the plants treated with both the fungus and the nematode were much

smaller and the plants had an unhealthy appearance, compared with those plants treated with fungus alone.

Some of the plants, inoculated with only the *Glomus* spores, produced flowers as early as thirty days after inoculation, whereas flowering did not occur on those plants treated with both *Glomus* spores and nematodes, although flower buds were initiated. There was a difference of as much as 40% between the fresh weight of the top growth of plants treated with both *Glomus* spores and nematodes and those treated with *Glomus* spores alone, but only a 12,9% difference between those plants treated with both *Glomus* spores and nematodes and the control plants. The average fresh weight of the roots which received both the fungus and the nematode treatments was not different from the fresh weight of the control plants. However, a difference in fresh weight of as much as 45% occurred between plants receiving *Glomus* spores alone and those that received *Glomus* spores plus nematodes. From this table it can also be seen that simultaneous addition of both the nematode and the fungus resulted in plants having an average of only 3 nodules whereas the plants treated with *Glomus* spores had an average of 24 nodules. Between 70 ans 80 spores per 250 ml were recovered from the soil which received only the *Glomus* spores but only 15 to 20 spores and 4 073 nematodes per 250 ml soil were recovered from the soil which received both the nematode and the fungus.

TABLE 1 — THE NUMBER OF NODULES, THE FRESH WEIGHT OF ROOTS AND SHOOTS AND SHOOT HEIGHT OF SOYBEAN PLANTS (AVERAGE OF 5 PLANTS) 45 DAYS AFTER INOCULATION.

Soil treatments	*Number of nodules*	*Fresh Weight*		*Height of shoot*
		Shoot	*Root*	
		g	g	cm
Control	9	4,09	3,21	25,48
100 *Glomus* spores	24	5,94	5,62	34,64
100 *Glomus* spores + 32 000 nematodes/plant	3	3,56	3,61	20,12
LSD: P = 0,05	14,7	1,05	1,11	7,42

DISCUSSION

The most important result from this study was the discovery of an antagonistic interaction between *A. avenae* and a vesicular-arbuscular mycorrhizal fungus, *Glomus* sp., on the Altona cultivar of soybean. As the number of nematodes increased, there was a slight reduction in shoot weight which corresponded to the observed stunting of the plants. The leaf areas were also relatively smaller.

Several workers have indicated that *A. avenae* is primarily fungivorous and this conclusion probably led Roy (1973) and Porth (1975) to claim that *A. avenae* is a beneficial mycophagous nematode. The authors indicated that when many *A. avenae* are present they may aid in the control of fungus diseases of plant roots. In the present study, all attempts to culture the *Glomus* sp. on nutrient medium, to see where or how *A. avenae* was feeding on it, failed. This was not unexpected, because previous investigators have also failed to culture fungi of this genus. However, the results of the pot experiments showed that the addition of 32 000 nematodes per 15 cm clay pot was detrimental to the sporulation of the species of *Glomus* used in the experiment.

According to Asai (1964), nodulation of the roots of leguminous plants is enhanced in the presence of certain mycorrhizal fungi. The result of the present study showed that there were more nodules on the Altona soybeans in the presence than in the absence of an endomycorrhizal fungus. However, when *A. avenae* was added with the fungal inoculum, the number of nodules on the roots was greatly reduced. Van Schreven (1958) showed that an adequate phosphorus supply is important for satisfactory nodulation and nitrogen fixation ; it is therefore possible that *A. avenae* destroyed so much of the mycorrhizal fungus hyphae in the rhizosphere that it indirectly reduced the uptake of essential nutrients, including P, from the soil. This would have an adverse effect on nodulation and on the growth of the plant.

REFERENCES

Asai, T. 1964. Uber die Mycorrhizenbilding der Leguminosen-pflanzen, *Jpn. J. Bot.* **13:** 463-485.

Baltruschat, H., R. A. Sikora and F. Schonbeck. 1973. Effect of VA mycorrhiza on the establishment of *Thielaviopsis basicola* and *Meloidogyne incognita* on tobacco. *2nd Int. Congr. Plant Pathol. Abstract* **661**.

Caveness, F. E. and H. J. Jensen. 1955. Modification of the centrifugal-flotation technique for the isolation and concentration of nematodes and their eggs from soil and plant tissue. *Proc. Helminthol. Soc. Wash.* **22:** 87-89.

Porth, R. B. 1975. Studies on the biology and feeding habits of selected nematodes from the rhizosphere of legumes. Ph.D. Thesis, McGill University. pp. 142.

Ross, J. P. 1972. Influence of Endogone mycorrhiza on Phytophthora rot of soybean. *Phytopathology* **62:** 896-897.

Roy, A. K. 1973. Effects of *Aphelenchus avenae* on tomato plants infected with *Rhizoctonia solani* and *Colletotrichum coccodes*. *Z. Pflanzenkr. Pflanzenschutz.* **80:** 23-33.

Salawu, O. 1977. Soybeans, Selected Nematodes and Fungi. M.Sc. Thesis, McGill University, pp. 121.

Schenk, N.C., R. A. Kinlock and D. W. Dickson. 1975. Interaction of endomycorrhizal fungi and root-knot nematode of soybean. *In :* Endomycorrhizas (Ed. by F. E. Sanders, Barbara Mosse and P. B. Tinker). London : Academic Press. pp. 607.

Van Schreven, D. A. 1958. Some factors affecting the uptake of nitrogen by legumes. *In :* Nutrition of the Legumes (Ed. by E. G. Hallsworth), London, Butterworths. pp. 137.

(Accepted for publication April 9, 1979).